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Высшая школа программной инженерии

Получение выходного сигнала с помощью КИХ-фильтра
Расчетное задание №2 по курсу
Цифровая обработка и передача многомерных сигналов

Вариант № 7

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Задание

Есть импульсный отклик ЛИС-системы $h(n_1\ ,n_2)$. Необходимо найти реакцию системы на входной сигнал $x(n_1\ ,n_2)$ двумя способами:
1) с помощью дискретной свертки: $y(n_1\ ,n_2)$ = $h(n_1\ ,n_2)$ ** $x(n_1\ ,n_2)$;
2) путем суммирования взвешенных и сдвинутых импульсных откликов;

$$h(n_1\ ,n_2) = \begin{array}{cc} \begin{array}{ccccccc} & & \uparrow\ n_2 & & & & \end{array} & \\ \begin{pmatrix} 3 & 3 & 2 & 2 & 1 & 1 & 2 \\ 1 & 1 & 4 & 3 & 3 & 2 & 0 \\ 2 & 2 & 3 & 4 & 0 & 5 & 4 \\ 2 & 4 & 3 & 3 & 2 & 1 & 0 \\ 0 & 4 & 2 & 0 & 3 & 6 & 5 \\ 0 & 3 & 2 & 4 & 7 & 5 & 7 \\ 0 & 3 & 3 & 0 & 4 & 4 & 7 \end{pmatrix} & \underset{n_1}{\rightarrow} \end{array}$$

$$x(n_1\ ,n_2) = \begin{array}{cc} \begin{array}{ccccccc} & & \uparrow\ n_2 & & & & \end{array} & \\ \begin{pmatrix} 0 & 3 & 3 & 0 & 5 & 0 & 0 \\ 4 & 2 & 2 & 4 & 0 & 4 & 4 \\ 5 & 3 & 2 & 5 & 3 & 4 & 7 \\ 5 & 4 & 2 & 0 & 0 & 4 & 0 \\ 0 & 4 & 1 & 4 & 0 & 0 & 8 \\ 3 & 3 & 2 & 0 & 2 & 4 & 5 \\ 0 & 1 & 3 & 4 & 0 & 4 & 6 \\ 0 & 4 & 0 & 5 & 5 & 0 & 0 \end{pmatrix} & \underset{n_1}{\rightarrow} \end{array}$$

Подготовительный этап

Определим размер выходной матрицы y. Пусть h имеет размерность N 1 x N 2, а x – M 1 x M 2 . Тогда размерность матрицы y – L 1 x L 2 будет:

L 1 = N 1 + M 1 – 1 = 7 + 8 – 1 = 14

L 2 = N 2 + M 2 – 1 = 7 + 7 – 1 = 13

Текст программы

Программы для вычисления реакции системы написаны на языке C++ 11, в среде разработки Qt Creator 5.9.2. Программа для визуализации данных написана с использованием среды MatLab R2016a.

1) Вычисление дискретной свертки

```
#include <stdio.h>

#define H_ROW 7
#define H_COL 7
#define X_ROW 8
#define X_COL 7
#define Y_ROW (H_ROW + X_ROW - 1)
#define Y_COL (H_COL + X_COL - 1)

void PrintMatrix(FILE* file, int* matrix[], const char* type)
```

```
{
        int row, col;

        if (type == "H")
        {
                row = H_ROW;
                col = H_COL;
        } // (type == "H")
        else if (type == "X")
        {
                row = X_ROW;
                col = X_COL;
        } // (type == "X")
        else
        {
                row = Y_ROW;
                col = Y_COL;
        } // (type != "X") && (type != "H")

        fprintf(file, "======= Matrix %s(%d, %d)=======\n", type, row, col);

        for (int i = 0; i < row; i++)
        {
                for (int j = 0; j < col; j++)
                {
                        fprintf(file, "%d\t", matrix[i*col + j]);
                } // for (int j = 0; j < col; j++)

                fprintf(file, "\n");
        } // for (int i = 0; i < row; i++)

        fprintf(file, "\n\n");
}

int main()
{
        int h[H_ROW][H_COL] = { { 3, 3, 2, 2, 1, 1, 2 },
                                                        { 1, 1, 4, 3, 3, 2, 0 },
                                                        { 2, 2, 3, 4, 0, 5, 4 },
                                                        { 2, 4, 3, 3, 2, 1, 0 },
                                                        { 0, 4, 2, 0, 3, 6, 5 },
                                                        { 0, 3, 2, 4, 0, 5, 7 },
                                                        { 0, 3, 3, 0, 4, 4, 7 } };

        int x[X_ROW][X_COL] = { { 0, 3, 3, 0, 5, 0, 0 },
                                                        { 4, 2, 2, 4, 0, 4, 4 },
                                                        { 5, 3, 2, 5, 3, 4, 7 },
                                                        { 5, 4, 2, 0, 0, 4, 0 },
                                                        { 0, 4, 1, 4, 0, 0, 8 },
                                                        { 3, 3, 2, 0, 2, 4, 5 },
                                                        { 0, 1, 3, 4, 0, 4, 6 },
                                                        { 0, 4, 0, 5, 5, 0, 0 } };

        int y[Y_ROW][Y_COL];

        for (int i = 0; i < Y_ROW; i++)
        {
                for (int j = 0; j < Y_COL; j++)
                {
                        y[i][j] = 0;
                } // for(int j = 0; j < Y_COL; j++)
        } // for(int i = 0; i < Y_ROW; i++)

        for (int i = 0; i < Y_ROW; i++)
        {
                for (int j = 0; j < Y_COL; j++)
                {
                        for (int k1 = 0; k1 < H_ROW; k1++)
                        {
                                for (int k2 = 0; k2 < H_COL; k2++)
                                {
                                        if ((i - k1 >= 0) && (i - k1 < X_ROW) && (j - k2 < X_COL) && (j -
k2 >= 0))
                                        {
                                                y[i][j] += h[k1][k2] * x[i - k1][j - k2];

                                        } // if((i-k1 >= 0)&&(i-k1 < X_ROW)&&(j-k2 < X_COL)&&(j-k2 >= 0))
                                } // for(int k2 = 0; k2 < H_COL; k2++)
                        } // for(int k1 = 0; k1 < H_ROW; k1++)
                } // for(int j = 0; j < Y_COL; j++)
        } // for(int i = 0; i < Y_ROW; i++)

        FILE* file = fopen("../method_1.xls", "w");

        if (file != NULL)
        {
                PrintMatrix(file, (int**)h, "H");
                PrintMatrix(file, (int**)x, "X");
                PrintMatrix(file, (int**)y, "Y");

                fclose(file);
        } // if(file != NULL)

        return 0;
}
```

2) Суммирование взвешенных и сдвинутых импульсных откликов

```
#include <stdio.h>

#define H_ROW 7
#define H_COL 7
#define X_ROW 8
#define X_COL 7
#define Y_ROW (H_ROW + X_ROW - 1)
#define Y_COL (H_COL + X_COL - 1)

void PrintMatrix(FILE* file, int* matrix[], const char* type)
{
        int row, col;

        if (type == "H")
        {
                row = H_ROW;
                col = H_COL;
        } // (type == "H")
        else if (type == "X")
        {
                row = X_ROW;
                col = X_COL;
        } // (type == "X")
        else
        {
                row = Y_ROW;
                col = Y_COL;
        } // (type != "X") && (type != "H")

        fprintf(file, "======= Matrix %s(%d, %d)=======\n", type, row, col);

        for (int i = 0; i < row; i++)
        {
                for (int j = 0; j < col; j++)
                {
                        fprintf(file, "%d\t", matrix[i*col + j]);
                } // for (int j = 0; j < col; j++)

                fprintf(file, "\n");
        } // for (int i = 0; i < row; i++)

        fprintf(file, "\n\n");
}

int main(void)
{
        int h[H_ROW][H_COL] = { { 3, 3, 2, 2, 1, 1, 2 },
                                                        { 1, 1, 4, 3, 3, 2, 0 },
                                                        { 2, 2, 3, 4, 0, 5, 4 },
                                                        { 2, 4, 3, 3, 2, 1, 0 },
                                                        { 0, 4, 2, 0, 3, 6, 5 },
                                                        { 0, 3, 2, 4, 0, 5, 7 },
                                                        { 0, 3, 3, 0, 4, 4, 7 } };

        int x[X_ROW][X_COL] = { { 0, 3, 3, 0, 5, 0, 0 },
                                                        { 4, 2, 2, 4, 0, 4, 4 },
                                                        { 5, 3, 2, 5, 3, 4, 7 },
                                                        { 5, 4, 2, 0, 0, 4, 0 },
                                                        { 0, 4, 1, 4, 0, 0, 8 },
                                                        { 3, 3, 2, 0, 2, 4, 5 },
                                                        { 0, 1, 3, 4, 0, 4, 6 },
                                                        { 0, 4, 0, 5, 5, 0, 0 } };

        int temp[Y_ROW][Y_COL];
        int y[Y_ROW][Y_COL];

        for (int i = 0; i < Y_ROW; i++)
        {
                for (int j = 0; j < Y_COL; j++)
                {
                        y[i][j] = 0;
                } // (int j = 0; j < Y_COL; j++)
        } // (int i = 0; i < Y_ROW; i++)

        FILE* file = fopen("method_2.xls", "w");

        PrintMatrix(file, (int**)h, "H");
        PrintMatrix(file, (int**)x, "X");

        for (int k1 = 0; k1 < X_ROW; k1++)
        {
                for (int k2 = 0; k2 < X_COL; k2++)
                {
                        for (int i = 0; i < Y_ROW; i++)
                        {
                                for (int j = 0; j < Y_COL; j++)
                                {
                                        temp[i][j] = 0;
                                } // for (int j = 0; j < Y_COL; j++)
                        } // (int i = 0; i < Y_ROW; i++)

                        for (int m1 = 0; m1 < H_ROW; m1++)
                        {
                                for (int m2 = 0; m2 < H_COL; m2++)
                                {
                                        temp[m1 + k1][m2 + k2] = h[m1][m2] * x[k1][k2];
                                } // (int m2 = 0; m2 < H_COL; m2++)
                        } // (int m1 = 0; m1 < H_ROW; m1++)

                        char matr[12] = "";
                        sprintf(matr, "Temp_%d_%d", k1 + 1, k2 + 1);

                        PrintMatrix(file, (int**)temp, matr);

                        for (int i = 0; i < Y_ROW; i++)
                        {
                                for (int j = 0; j < Y_COL; j++)
                                {
                                        y[i][j] += temp[i][j];
                                } // (int j = 0; j < Y_COL; j++)
                        } // (int i = 0; i < Y_ROW; i++)
                } // (int k2 = 0; k2 < X_COL; k2++)
        } // (int k1 = 0; k1 < X_ROW; k1++)

        PrintMatrix(file, (int**)y, "Y");

        fclose(file);
}
```

3) Построение 3D графиков реакции системы.

```
function [] = plot_out_signals()
%% PLOT_OUT_SIGNALS
% Summary of this function goes here.
%
% * Syntax
%
% [] = PLOT_OUT_SIGNALS()
%
% * Input
%
% -- INPUTARGS  -
%
% * Output
```

```
%
% -- OUTPUTARGS  -
%
% * Examples:
%
% Provide sample usage code here
%
% * See also:
%
% List related files here
%
% * Author: Dmitrii Leliuhin
% * Email:  dleliuhin@mail.ru
% * Date: 31/03/2019 15:18:11
% * Version:  1.0 $
% * Requirements:  PCWIN64, MatLab R2016a
%
% * Warning:
%
% # Warnings list.
%
% * TODO:
%
% # TODO list.
%

%% Code
clc;
clear all;
close all;

y.rows = 14;
y.cols = 13;

file_name_1  = '../results/method_1.xls';
file_name_2  = '../results/method_2.xls';

Y_1 = zeros(y.rows, y.cols);
Y_2 = zeros(y.rows, y.cols);

xls_range_1 = 'A23:M36';
xls_range_2 = 'A975:M988';

Y_1 = xlsread(file_name_1,  xls_range_1);
Y_2 = xlsread(file_name_2,  xls_range_2);

figure;
title('Метод  1. Вычисление  дискретной  свертки.', 'FontSize', 18);
surf(Y_1)
saveas(gcf, '../results/method_1', 'jpg');

figure;
title('Метод  2. Суммирование  взвешенных  и сдвинутых  импульсных  откликов.', ...
    'FontSize', 18);
surf(Y_2)
saveas(gcf, '../results/method_2', 'jpg');

figure;
surf(Y_1);
view(2);
snapnow;
saveas(gcf, '../results/2D-view', 'jpg');

save('../results/workspace.mat');

close all;
end
```

Результаты

1) Вычисление дискретной свертки

$y(n_1\ ,n_2)$

0	9	18	15	27	24	16	19	11	5	10	0	0
12	21	26	45	50	53	79	51	39	30	8	12	8
19	36	57	78	100	105	124	131	82	80	57	23	14
28	53	91	113	107	160	160	125	137	80	53	58	16
23	57	102	151	133	171	220	188	162	149	85	63	44
29	82	109	144	162	217	261	270	195	129	146	96	30
13	77	119	161	175	221	323	272	290	230	152	174	107
6	80	116	143	194	249	357	330	242	233	177	188	97
6	54	99	125	147	209	293	311	264	158	143	183	113
0	37	75	88	133	139	268	243	142	171	101	124	81
0	17	47	75	95	111	137	226	153	95	108	141	121
0	9	37	34	60	92	126	139	151	131	95	106	77
0	0	15	20	52	41	78	113	80	104	75	52	42
0	0	12	12	15	46	31	48	40	55	35	0	0

2) Суммирование взвешенных и сдвинутых импульсных откликов

$h(n_1\ ,n_2) * x(8,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(8,2)$

0	9	9	6	6	3	3	6	0	0	0	0	0
0	3	3	12	9	9	6	0	0	0	0	0	0
0	6	6	9	12	0	15	12	0	0	0	0	0
0	6	12	9	9	6	3	0	0	0	0	0	0
0	0	12	6	0	9	18	15	0	0	0	0	0
0	0	9	6	12	0	15	21	0	0	0	0	0
0	0	9	9	0	12	12	21	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(8,3)$

0	0	9	9	6	6	3	3		6	0	0	0	0
0	0	3	3	12	9	9	6		0	0	0	0	0
0	0	6	6	9	12	0	15		12	0	0	0	0
0	0	6	12	9	9	6	3		0	0	0	0	0
0	0	0	12	6	0	9	18		15	0	0	0	0
0	0	0	9	6	12	0	15		21	0	0	0	0
0	0	0	9	9	0	12	12		21	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0

$h(n_1\ ,n_2) * x(8,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(8,5)$

0	0	0	0	15	15	10	10	5	5	10	0	0
0	0	0	0	5	5	20	15	15	10	0	0	0
0	0	0	0	10	10	15	20	0	25	20	0	0
0	0	0	0	10	20	15	15	10	5	0	0	0
0	0	0	0	0	20	10	0	15	30	25	0	0
0	0	0	0	0	15	10	20	0	25	35	0	0
0	0	0	0	0	15	15	0	20	20	35	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(8,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(8,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

==

$h(n_1\ , n_2) * x(7,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
12	12	8	8	4	4	8	0	0	0	0	0	0
4	4	16	12	12	8	0	0	0	0	0	0	0
8	8	12	16	0	20	16	0	0	0	0	0	0
8	16	12	12	8	4	0	0	0	0	0	0	0
0	16	8	0	12	24	20	0	0	0	0	0	0
0	12	8	16	0	20	28	0	0	0	0	0	0
0	12	12	0	16	16	28	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(7,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	6	6	4	4	2	2	4	0	0	0	0	0
0	2	2	8	6	6	4	0	0	0	0	0	0
0	4	4	6	8	0	10	8	0	0	0	0	0
0	4	8	6	6	4	2	0	0	0	0	0	0
0	0	8	4	0	6	12	10	0	0	0	0	0
0	0	6	4	8	0	10	14	0	0	0	0	0
0	0	6	6	0	8	8	14	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(7,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6	6	4	4	2	2	4	0	0	0	0
0	0	2	2	8	6	6	4	0	0	0	0	0
0	0	4	4	6	8	0	10	8	0	0	0	0
0	0	4	8	6	6	4	2	0	0	0	0	0
0	0	0	8	4	0	6	12	10	0	0	0	0
0	0	0	6	4	8	0	10	14	0	0	0	0
0	0	0	6	6	0	8	8	14	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(7,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	12	12	8	8	4	4	8	0	0	0
0	0	0	4	4	16	12	12	8	0	0	0	0
0	0	0	8	8	12	16	0	20	16	0	0	0
0	0	0	8	16	12	12	8	4	0	0	0	0
0	0	0	0	16	8	0	12	24	20	0	0	0
0	0	0	0	12	8	16	0	20	28	0	0	0
0	0	0	0	12	12	0	16	16	28	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(7,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(7,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12	12	8	8	4	4	8	0
0	0	0	0	0	4	4	16	12	12	8	0	0
0	0	0	0	0	8	8	12	16	0	20	16	0
0	0	0	0	0	8	16	12	12	8	4	0	0
0	0	0	0	0	0	16	8	0	12	24	20	0
0	0	0	0	0	0	12	8	16	0	20	28	0
0	0	0	0	0	0	12	12	0	16	16	28	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(7,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	12	12	8	8	4	4	8
0	0	0	0	0	0	4	4	16	12	12	8	0
0	0	0	0	0	0	8	8	12	16	0	20	16
0	0	0	0	0	0	8	16	12	12	8	4	0
0	0	0	0	0	0	0	16	8	0	12	24	20
0	0	0	0	0	0	0	12	8	16	0	20	28
0	0	0	0	0	0	0	12	12	0	16	16	28
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

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$h(n_1\ ,n_2) * x(6,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
15	15	10	10	5	5	10	0	0	0	0	0	0
5	5	20	15	15	10	0	0	0	0	0	0	0
10	10	15	20	0	25	20	0	0	0	0	0	0
10	20	15	15	10	5	0	0	0	0	0	0	0
0	20	10	0	15	30	25	0	0	0	0	0	0
0	15	10	20	0	25	35	0	0	0	0	0	0
0	15	15	0	20	20	35	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(6,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	9	9	6	6	3	3	6	0	0	0	0	0
0	3	3	12	9	9	6	0	0	0	0	0	0
0	6	6	9	12	0	15	12	0	0	0	0	0
0	6	12	9	9	6	3	0	0	0	0	0	0
0	0	12	6	0	9	18	15	0	0	0	0	0
0	0	9	6	12	0	15	21	0	0	0	0	0
0	0	9	9	0	12	12	21	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(6,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6	6	4	4	2	2	4	0	0	0	0
0	0	2	2	8	6	6	4	0	0	0	0	0
0	0	4	4	6	8	0	10	8	0	0	0	0
0	0	4	8	6	6	4	2	0	0	0	0	0
0	0	0	8	4	0	6	12	10	0	0	0	0
0	0	0	6	4	8	0	10	14	0	0	0	0
0	0	0	6	6	0	8	8	14	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(6,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	15	15	10	10	5	5	10	0	0	0
0	0	0	5	5	20	15	15	10	0	0	0	0

0	0	0	10	10	15	20	0	25	20	0	0	0
0	0	0	10	20	15	15	10	5	0	0	0	0
0	0	0	0	20	10	0	15	30	25	0	0	0
0	0	0	0	15	10	20	0	25	35	0	0	0
0	0	0	0	15	15	0	20	20	35	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1 ,n_2) * x(6,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	9	9	6	6	3	3	6	0	0
0	0	0	0	3	3	12	9	9	6	0	0	0
0	0	0	0	6	6	9	12	0	15	12	0	0
0	0	0	0	6	12	9	9	6	3	0	0	0
0	0	0	0	0	12	6	0	9	18	15	0	0
0	0	0	0	0	9	6	12	0	15	21	0	0
0	0	0	0	0	9	9	0	12	12	21	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1 ,n_2) * x(6,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12	12	8	8	4	4	8	0

0	0	0	0	0	4	4	16	12	12	8	0	0
0	0	0	0	0	8	8	12	16	0	20	16	0
0	0	0	0	0	8	16	12	12	8	4	0	0
0	0	0	0	0	0	16	8	0	12	24	20	0
0	0	0	0	0	0	12	8	16	0	20	28	0
0	0	0	0	0	0	12	12	0	16	16	28	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1 ,n_2) * x(6,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	21	21	14	14	7	7	14
0	0	0	0	0	0	7	7	28	21	21	14	0
0	0	0	0	0	0	14	14	21	28	0	35	28
0	0	0	0	0	0	14	28	21	21	14	7	0
0	0	0	0	0	0	0	28	14	0	21	42	35
0	0	0	0	0	0	0	21	14	28	0	35	49
0	0	0	0	0	0	0	21	21	0	28	28	49
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

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$h(n_1 ,n_2) * x(5,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
15	15	10	10	5	5	10	0	0	0	0	0	0
5	5	20	15	15	10	0	0	0	0	0	0	0
10	10	15	20	0	25	20	0	0	0	0	0	0
10	20	15	15	10	5	0	0	0	0	0	0	0
0	20	10	0	15	30	25	0	0	0	0	0	0
0	15	10	20	0	25	35	0	0	0	0	0	0
0	15	15	0	20	20	35	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1 ,n_2) * x(5,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	12	12	8	8	4	4	8	0	0	0	0	0
0	4	4	16	12	12	8	0	0	0	0	0	0
0	8	8	12	16	0	20	16	0	0	0	0	0
0	8	16	12	12	8	4	0	0	0	0	0	0
0	0	16	8	0	12	24	20	0	0	0	0	0
0	0	12	8	16	0	20	28	0	0	0	0	0
0	0	12	12	0	16	16	28	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1 ,n_2) * x(5,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6	6	4	4	2	2	4	0	0	0	0
0	0	2	2	8	6	6	4	0	0	0	0	0
0	0	4	4	6	8	0	10	8	0	0	0	0

0	0	4	8	6	6	4	2	0	0	0	0	0
0	0	0	8	4	0	6	12	10	0	0	0	0
0	0	0	6	4	8	0	10	14	0	0	0	0
0	0	0	6	6	0	8	8	14	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(5,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(5,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(5,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12	12	8	8	4	4	8	0
0	0	0	0	0	4	4	16	12	12	8	0	0
0	0	0	0	0	8	8	12	16	0	20	16	0
0	0	0	0	0	8	16	12	12	8	4	0	0
0	0	0	0	0	0	16	8	0	12	24	20	0
0	0	0	0	0	0	12	8	16	0	20	28	0
0	0	0	0	0	0	12	12	0	16	16	28	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(5,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

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$h(n_1\ , n_2) * x(4,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(4,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	12	12	8	8	4	4	8	0	0	0	0	0
0	4	4	16	12	12	8	0	0	0	0	0	0
0	8	8	12	16	0	20	16	0	0	0	0	0
0	8	16	12	12	8	4	0	0	0	0	0	0
0	0	16	8	0	12	24	20	0	0	0	0	0
0	0	12	8	16	0	20	28	0	0	0	0	0
0	0	12	12	0	16	16	28	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(4,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	3	3	2	2	1	1	2	0	0	0	0
0	0	1	1	4	3	3	2	0	0	0	0	0
0	0	2	2	3	4	0	5	4	0	0	0	0
0	0	2	4	3	3	2	1	0	0	0	0	0
0	0	0	4	2	0	3	6	5	0	0	0	0
0	0	0	3	2	4	0	5	7	0	0	0	0
0	0	0	3	3	0	4	4	7	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$$h(n_1 ,n_2) * x(4,4)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	12	12	8	8	4	4	8	0	0	0
0	0	0	4	4	16	12	12	8	0	0	0	0
0	0	0	8	8	12	16	0	20	16	0	0	0
0	0	0	8	16	12	12	8	4	0	0	0	0
0	0	0	0	16	8	0	12	24	20	0	0	0
0	0	0	0	12	8	16	0	20	28	0	0	0
0	0	0	0	12	12	0	16	16	28	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$$h(n_1 ,n_2) * x(4,5)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$$h(n_1 ,n_2) * x(4,6)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$$h(n_1 ,n_2) * x(4,7)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	24	24	16	16	8	8	16
0	0	0	0	0	0	8	8	32	24	24	16	0
0	0	0	0	0	0	16	16	24	32	0	40	32
0	0	0	0	0	0	16	32	24	24	16	8	0
0	0	0	0	0	0	0	32	16	0	24	48	40
0	0	0	0	0	0	0	24	16	32	0	40	56
0	0	0	0	0	0	0	24	24	0	32	32	56
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

==

$$h(n_1 ,n_2) * x(3,1)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	6	6	3	3	6	0	0	0	0	0	0
3	3	12	9	9	6	0	0	0	0	0	0	0
6	6	9	12	0	15	12	0	0	0	0	0	0
6	12	9	9	6	3	0	0	0	0	0	0	0
0	12	6	0	9	18	15	0	0	0	0	0	0
0	9	6	12	0	15	21	0	0	0	0	0	0
0	9	9	0	12	12	21	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$$h(n_1 ,n_2) * x(3,2)$$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	9	9	6	6	3	3	6	0	0	0	0	0
0	3	3	12	9	9	6	0	0	0	0	0	0
0	6	6	9	12	0	15	12	0	0	0	0	0
0	6	1	9	9	6	3	0	0	0	0	0	0

		2										
0	0	12	6	0	9	18	15	0	0	0	0	0
0	0	9	6	12	0	15	21	0	0	0	0	0
0	0	9	9	0	12	12	21	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(3,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6	6	4	4	2	2	4	0	0	0	0
0	0	2	2	8	6	6	4	0	0	0	0	0
0	0	4	4	6	8	0	10	8	0	0	0	0
0	0	4	8	6	6	4	2	0	0	0	0	0
0	0	0	8	4	0	6	12	10	0	0	0	0
0	0	0	6	4	8	0	10	14	0	0	0	0
0	0	0	6	6	0	8	8	14	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(3,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(3,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	6	6	4	4	2	2	4	0	0
0	0	0	0	2	2	8	6	6	4	0	0	0

0	0	0	0	4	4	6	8	0	10	8	0	0
0	0	0	0	4	8	6	6	4	2	0	0	0
0	0	0	0	0	8	4	0	6	12	10	0	0
0	0	0	0	0	6	4	8	0	10	14	0	0
0	0	0	0	0	6	6	0	8	8	14	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(3,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12	12	8	8	4	4	8	0
0	0	0	0	0	4	4	16	12	12	8	0	0
0	0	0	0	0	8	8	12	16	0	20	16	0
0	0	0	0	0	8	16	12	12	8	4	0	0
0	0	0	0	0	0	16	8	0	12	24	20	0
0	0	0	0	0	0	12	8	16	0	20	28	0
0	0	0	0	0	0	12	12	0	16	16	28	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(3,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	15	15	10	10	5	5	10
0	0	0	0	0	0	5	5	20	15	15	10	0
0	0	0	0	0	0	10	10	15	20	0	25	20
0	0	0	0	0	0	10	20	15	15	10	5	0
0	0	0	0	0	0	0	20	10	0	15	30	25
0	0	0	0	0	0	0	15	10	20	0	25	35
0	0	0	0	0	0	0	15	15	0	20	20	35
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

===

$h(n_1\ ,n_2) * x(2,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(2,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	3	2	2	1	1	2	0	0	0	0	0

0	1	1	4	3	3	2	0	0	0	0	0	0
0	2	2	3	4	0	5	4	0	0	0	0	0
0	2	4	3	3	2	1	0	0	0	0	0	0
0	0	4	2	0	3	6	5	0	0	0	0	0
0	0	3	2	4	0	5	7	0	0	0	0	0
0	0	3	3	0	4	4	7	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(2,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	9	9	6	6	3	3	6	0	0	0	0
0	0	3	3	12	9	9	6	0	0	0	0	0
0	0	6	6	9	12	0	15	12	0	0	0	0
0	0	6	12	9	9	6	3	0	0	0	0	0
0	0	0	12	6	0	9	18	15	0	0	0	0
0	0	0	9	6	12	0	15	21	0	0	0	0
0	0	0	9	9	0	12	12	21	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(2,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	12	12	8	8	4	4	8	0	0	0
0	0	0	4	4	16	12	12	8	0	0	0	0
0	0	0	8	8	12	16	0	20	16	0	0	0
0	0	0	8	16	12	12	8	4	0	0	0	0
0	0	0	0	16	8	0	12	24	20	0	0	0
0	0	0	0	12	8	16	0	20	28	0	0	0
0	0	0	0	12	12	0	16	16	28	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(2,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(2,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12	12	8	8	4	4	8	0
0	0	0	0	0	4	4	16	12	12	8	0	0
0	0	0	0	0	8	8	12	16	0	20	16	0
0	0	0	0	0	8	16	12	12	8	4	0	0
0	0	0	0	0	0	16	8	0	12	24	20	0
0	0	0	0	0	0	12	8	16	0	20	28	0
0	0	0	0	0	0	12	12	0	16	16	28	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(2,7)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	18	18	12	12	6	6	12
0	0	0	0	0	0	6	6	24	18	18	12	0
0	0	0	0	0	0	12	12	18	24	0	30	24
0	0	0	0	0	0	12	24	18	18	12	6	0
0	0	0	0	0	0	0	24	12	0	18	36	30
0	0	0	0	0	0	0	18	12	24	0	30	42
0	0	0	0	0	0	0	18	18	0	24	24	42
0	0	0	0	0	0	0	0	0	0	0	0	0

===

$h(n_1\ , n_2) * x(1,1)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ , n_2) * x(1,2)$

0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	12	12	8	8	4	4	8	0	0	0	0	0
0	4	4	16	12	12	8	0	0	0	0	0	0
0	8	8	12	16	0	20	16	0	0	0	0	0
0	8	16	12	12	8	4	0	0	0	0	0	0
0	0	16	8	0	12	24	20	0	0	0	0	0
0	0	12	8	16	0	20	28	0	0	0	0	0
0	0	12	12	0	16	16	28	0	0	0	0	0

$h(n_1\ ,n_2) * x(1,3)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(1,4)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	15	15	10	10	5	5	10	0	0	0
0	0	0	5	5	20	15	15	10	0	0	0	0
0	0	0	10	10	15	20	0	25	20	0	0	0
0	0	0	10	20	15	15	10	5	0	0	0	0
0	0	0	0	20	10	0	15	30	25	0	0	0
0	0	0	0	15	10	20	0	25	35	0	0	0

0	0	0	0	15	15	0	20	20	35	0	0	0

$h(n_1\ ,n_2) * x(1,5)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	15	15	10	10	5	5	10	0	0
0	0	0	0	5	5	20	15	15	10	0	0	0
0	0	0	0	10	10	15	20	0	25	20	0	0
0	0	0	0	10	20	15	15	10	5	0	0	0
0	0	0	0	0	20	10	0	15	30	25	0	0
0	0	0	0	0	15	10	20	0	25	35	0	0
0	0	0	0	0	15	15	0	20	20	35	0	0

$h(n_1\ ,n_2) * x(1,6)$

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

$h(n_1\ ,n_2) * x(1,7)$

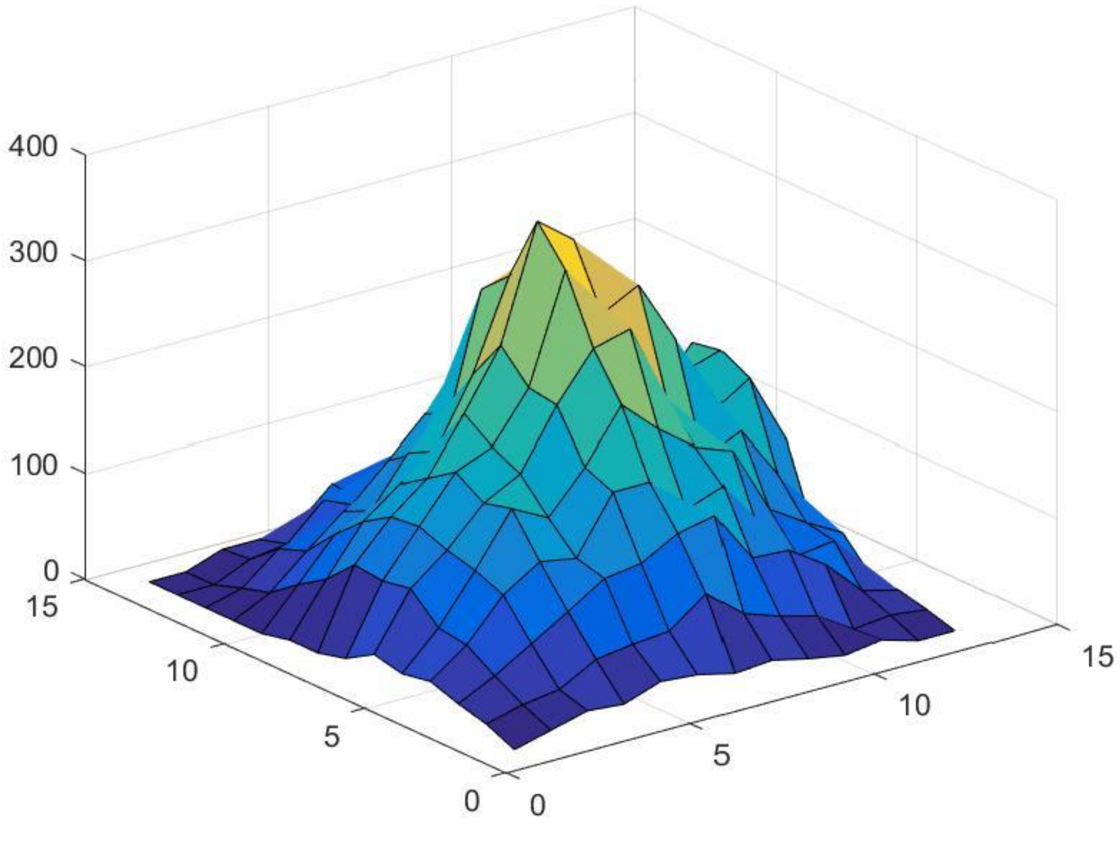
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

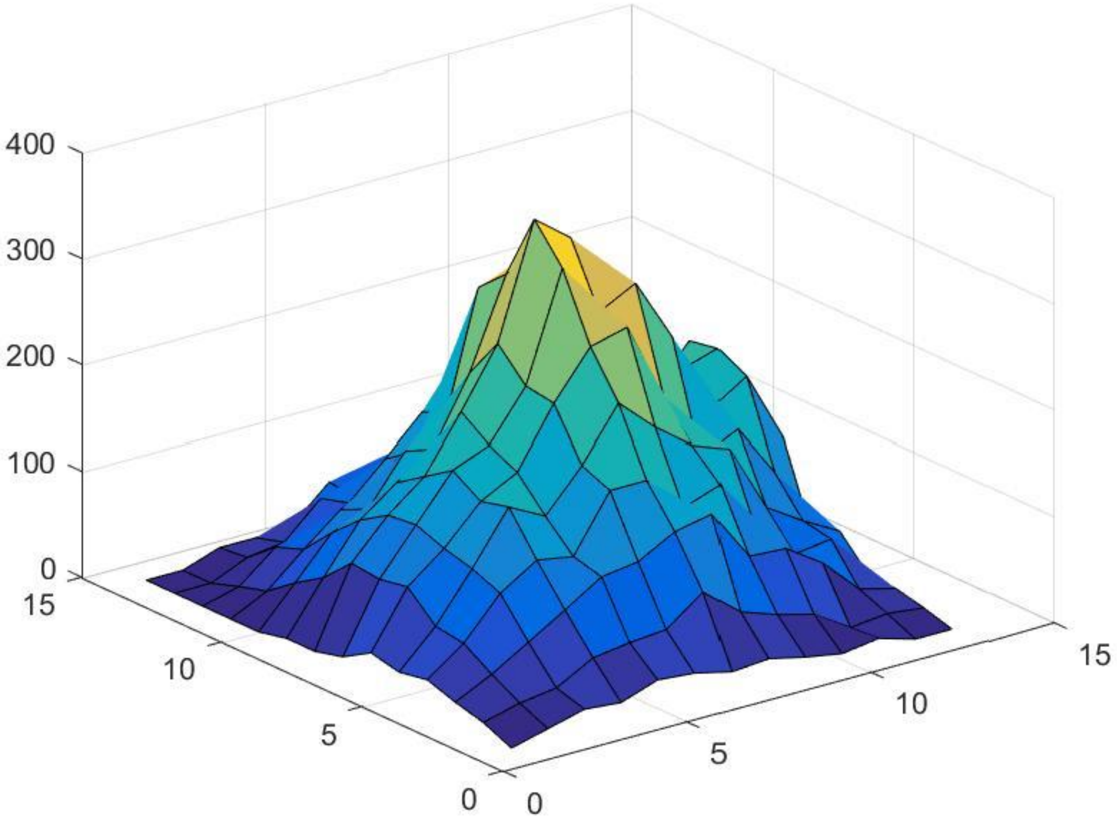
$y(n_1\ ,n_2)$

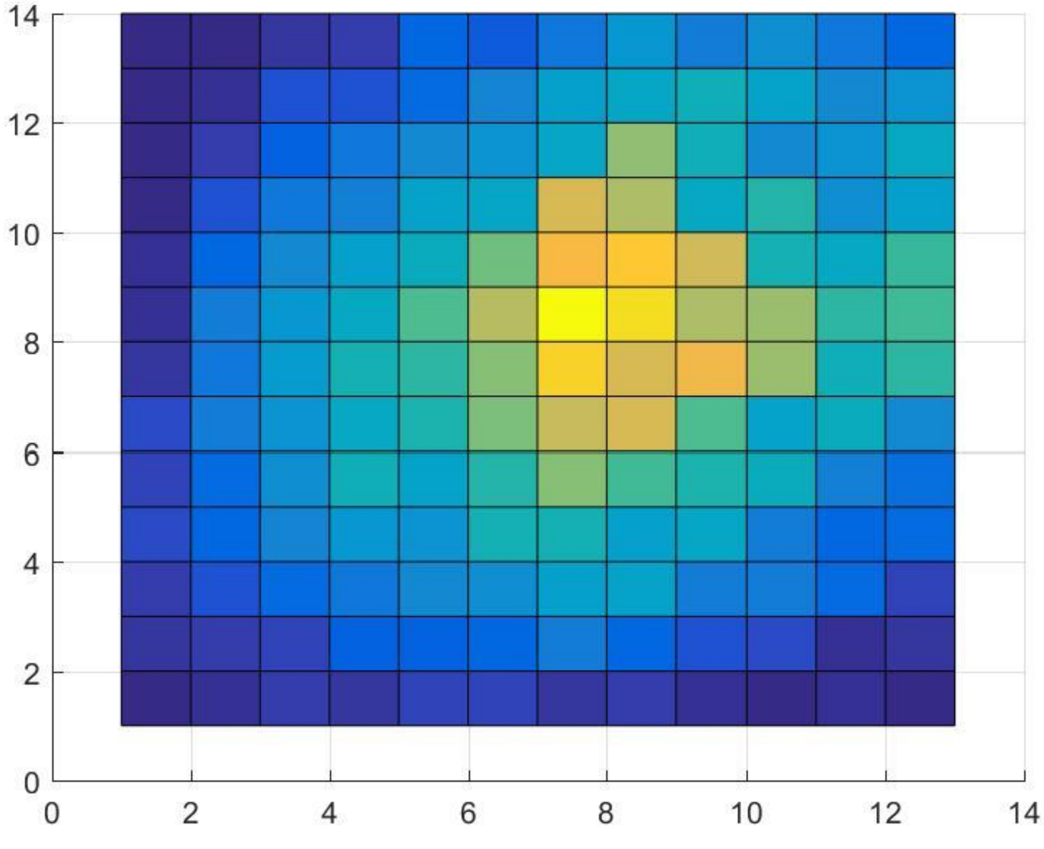
0	9	18	15	27	24	16	19	11	5	10	0	0
12	21	26	45	50	53	79	51	39	30	8	12	8
19	36	57	78	100	105	124	131	82	80	57	23	14
28	53	91	113	107	160	160	125	137	80	53	58	16
23	57	102	151	133	171	220	188	162	149	85	63	44
29	82	109	144	162	217	261	270	195	129	146	96	30
13	77	119	161	175	221	323	272	290	230	152	174	107
6	80	116	143	194	249	357	330	242	233	177	188	97
6	54	99	125	147	209	293	311	264	158	143	183	113
0	37	75	88	133	139	268	243	142	171	101	124	81
0	17	47	75	95	111	137	226	153	95	108	141	121
0	9	37	34	60	92	126	139	151	131	95	106	77
0	0	15	20	52	41	78	113	80	104	75	52	42
0	0	12	12	15	46	31	48	40	55	35	0	0

Графическое представление выходного сигнала

Графики построены в среде MatLab R2016a.




400
300
200
100
0
15
10
5
0
0
5
10
15


14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14

Выводы

В ходе работы была найдена реакция импульсного отклика ЛИС-системы $h(n_1\ ,n_2)$ на входной сигнал $x(n_1\ ,n_2)$ двумя способами:
1) с помощью дискретной свертки: $y(n_1\ ,n_2)$ = $h(n_1\ ,n_2)$ ** $x(n_1\ ,n_2)$;
2) путем суммирования взвешенных и сдвинутых импульсных откликов;

Для этого были написаны программы для вычисления реакции $y(n_1\ ,n_2)$ системы двумя вышеперечисленными способами на языке C++. Результирующие массивы $y(n_1\ ,n_2)$ получились идентичными в обоих случаях, что подтверждает достоверность вычислений. Также были построены 3D графики для $y(n_1\ ,n_2)$ для визуализации многомерного выходного сигнала.